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(19) (CA) **APPLICATION FOR CANADIAN PATENT** (12)

(54) Variable Color LED Device and LED Color Control Device

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Notice: This application is as filed and may therefore contain an incomplete specification.

## Abstract of the Disclosure

A variable color LED device emits variations of luminescent colors, and an LED color control device (current control circuit) controls the emission (color and intensity) from the variable color LED device. Luminescent diodes R, G, and B are provided in a single variable color LED device 10 to emit light of red, green, and blue. The electric current flowing to the luminescent diodes is controlled for each color by a current control circuit 15. The current control circuit 15 comprises, for example, variable resistances 16r, 16g, and 16b. Optionally controlling the electric current through the variable resistances allows the quantity of light of each of optical three primary colors, thereby emitting a mixed color from the luminescent diodes of the variable color LED device 10. Thus, variations of luminescent colors can be successfully emitted. The device can be used both indoors and outdoors as a display picture element for a color display device, etc. Its small picture element realizes a precise image.

**What is Claimed is:**

1. A variable color LED device, comprising:

luminescent diodes for each of optical three primary colors.

2. The variable color LED device according to Claim 1, further comprising:

a plurality of luminescent diodes for each of the optical three primary colors.

3. A LED color control device comprising a variable resistance circuit having a plurality of variable resistances mounted on a foundation base with luminescent diodes for each of optical three primary colors, wherein

said variable resistances are connected to one or more terminals of said luminescent diodes for each of the optical three primary colors to variably control an electric current flowing in one or more luminescent diodes.

4. A LED color control device having a variable resistance circuit having a plurality of variable resistances luminescent assembled in a body with

luminescent diodes for each of optical three primary colors, wherein

said variable resistances are connected to one or more terminals of the luminescent diodes for each of the optical three primary colors to variably control an electric current flowing in one or more luminescent diodes.

5. A variable color LED device comprising:

one or more luminescent diodes corresponding to each of optical three primary colors, wherein

a terminal unit of said luminescent diodes is made of hard metal in a plug shape as being mounted outside.

6. A LED color control device comprising:

a socket for connection to a plug-shaped hard metal terminal unit being mounted outside of a variable color LED device, wherein

said socket including a variable resistance circuit for connection to said plug; and

said variable resistance controls an electric current flowing in one or more luminescent diodes each of optical three primary colors of a variable color LED device.

# Variable Color LED Device and LED Color Control Device

## Background of the Invention

### Field of the Invention

The present invention relates to a variable color LED device which emits various colors and an LED color control device for controlling the emission (variations and intensity of colors) from the variable color LED device.

### Description of the Related Art

There have been luminescent elements used conventionally with various colored lights (for example, red, green). Particularly, a light emitting diode (LED) has been well-known as a small and power-saving device, and is used for various display devices.

FIG. 1A shows a top view of a conventional LED device. FIG. 1B shows the current control circuit of the LED device. An LED device 1 shown in FIG. 1A comprises a substrate 2 provided with a luminescent diode 3. The luminescent diode 3 is covered with a lens-shaped protective transmission cover. A current control circuit is connected to the LED device 1 as shown in FIG. 1B. The current control circuit

comprises terminal units 4 and 5 and a variable resistance 6. The terminal units 4 and 5 are connected to a power source with the terminal unit 4 directly connected to the cathode of the luminescent diode 3, and with the terminal unit 5 connected to the anode of the luminescent diode 3 through the variable resistance 6. The above described terminal units 4 and 5 are connected to the external power source (not shown in the attached drawings). When a bias voltage is applied in the forward direction with the above described configuration, the luminescent diode 3 emits light. The color of the emitted light depends on the material of the configuration of the luminescent diode 3. For example, when the configuration refers to Ga-As in the p-n junction, an infrared light is emitted. When the configuration refers to Ga-P with an $O_2$-doped semiconductor, a red light is emitted. When the configuration refers to Ga-P with an $N_2$-doped semiconductor, a green color is emitted. Furthermore, a luminescent diode emitting a blue light has recently been developed for practical use. The quantity of light emitted by a luminescent diode depends on the electric current flowing through a bias electric voltage. Therefore, the quantity of light can be changed by controlling the resistance value of the

variable resistance 6.

Such an LED device is designed to emit light of a single color from a single unit. For example, even if a plurality of luminescent diodes are mounted in a single LED device, the luminescent diodes are to emit light of a single (same) color.

Assuming that such LED devices are incorporated into a display device as picture elements, the picture elements of a common display device should be for various colors. Therefore, according to the related arts, LED devices separately emitting one of primaries are provided in three device units to obtain a desired color by mixing the luminescent colors from the three LED devices. One LED device is about 3 - 5mm in diameter. Therefore, a combination of 3 LED devices for optical three primary colors makes a display picture element as big as a circle circumscribing the three LED devices. As a result, one display picture element is 10 - 15mm in diameter.

It is 4 times as big as a single LED device, and is rather large as a display picture element. Even if the three LED devices are mounted closely to each other, the clearance between the luminescent diodes cannot be small enough to appropriately mix optical three primary colors. Therefore, even if the mixed

color may be acceptable when viewed from a distance, it has the problem when viewed closely that optical three primary colors cannot be sufficiently mixed, but are recognized separately. Under such conditions, forming a display device using conventional LED devices, each of which corresponds to a display picture element, makes up a very large display device, thereby unfavorably limiting the use of the device to the case where the device is viewed from a distance.

Furthermore, the LED devices for the above described combination should be provided as many as the number of requested colors for each use. Therefore, when the LED devices are prepared. three types of the LED devices should be assigned for optical three primary colors. The LED devices should also be assigned to each type of light quantity control corresponding to the light mixing ratio. Thus, there have been the problems that the LED devices give the users trouble in appropriately maintaining the LED devices as being classified corresponding to each type of luminescent color when they are manufactured and put on sales. There is another problem that the conventional devices require a considerably large store house to keep them in type units. Furthermore, in maintaining the display device

containing the LED devices, the luminescent colors and light quantity are incorrectly managed in the process of maintaining the display device containing the LED devices when a new LED device is flexibly used depending on the luminescent light. Additionally, troublesome operations are required to prevent the problems from occurring.

## Summary of the Invention

The present invention aims at solving the above listed problems associated with the prior art technologies. According to the present invention, An LED device is provided by mounting a luminescent diode emitting each of optical three primary colors on a substrate. This refers to a variable color LED device. The variable color LED device comprises a current control circuit for controlling corresponding to each color an electric current to be passed to each luminescent diode provided on the substrate. Configured as described above is the LED color control device.

Thus, the variable color LED device can emit any colors by configuring the LED color control device with the luminescent diode emitting each color of optical three primary colors on a single substrate,

and by controlling for each color the electric current to the luminescent diode. Thus, the LED device can be used as a small-size luminescent display picture element for various color display devices, signal devices, etc.

That is, the following effects can be obtained according to the variable color LED device and LED color control device of the present invention. First, since all colors can be emitted by one variable color LED device, a small-size luminescent display picture element can be realized for use outdoors and indoors in various color display device, signal device, etc., thereby obtaining an improved display picture image as compared with the combination of 3 LED devices each emitting a single color. Second, when the variable color LED device is used as a luminescent signal device emitting variations of colors, the number of signal lamps can be 1 regardless of the number of colors to be freely switched, thereby allowing much freedom in designing the signal lamp for its location and arrangement. Third, since a single variable color LED device can be used to emit all colors, it does not require separately storing for each color in manufacturing and sales processes. Even if it is incorporated into a display device, etc., the LED

device at hand does not have to be used only for a specified color, thereby removing trouble in storing the device, saving storage space for the stock, simplifying the assembly process, and allowing easy maintenance.

## Brief Description of the Drawings

FIG. 1A is a top view of the conventional LED device;

FIG. 1B shows the current control circuit of the LED device;

FIG. 2A is a top view of the variable color LED device according to the first embodiment of the present invention;

FIG. 2B is a side view of the variable color LED device according to the first embodiment of the present invention;

FIG. 2C is a bottom view of the variable color LED device according to the first embodiment of the present invention;

FIG. 3 shows the variable color LED device and the current control circuit for controlling current of the device according to the first embodiment of the present invention;

FIG. 4A is a top view of the variable color LED

device according to the second embodiment;

FIG. 4B shows the circuit of the variable color LED device and current control circuit;

FIG. 5A shows the variable color LED device and current control circuit for controlling the current of the device according to the third embodiment;

FIG. 5B shows the variable color LED device and current control circuit for controlling the current of the device according to the fourth embodiment;

FIG. 6 shows the variable color LED device and current control circuit for controlling the current of the device according to the fifth embodiment;

FIG. 7A shows the variable color LED device and current control circuit for controlling the current of the device according to the sixth embodiment;

FIG. 7B shows the variable color LED device and current control circuit for controlling the current of the device according to the seventh embodiment;

FIG. 8 shows the variable color LED device configured to emit light in various colors limited by the seventh embodiment of the present invention; and

FIG. 9 shows an example of the application of the variable color LED device according to the present invention to a signal lamp.

**Description of the Preferred Embodiments**

The embodiment according to the present invention is described below by referring to the attached drawings. FIG. 2A is the top view of the variable color LED device according to the first embodiment of the present invention; FIG. 2B is the side view of the device; and FIG. 2C is the bottom view of the device.

As shown in FIGs. 2A through 2C, a variable color LED device 10 comprises a circular substrate 12 on a body 11. On the substrate 12, three luminescent diodes R, G, and B are mounted. A protective cover 13 covers the substrate 12 and all these three luminescent diodes R, G, and B. Four terminal units 14r, 14g, 14b, and 14 are led from the bottom of the body 11.

The above described red luminescent diode R emits red light. The green luminescent diode G emits green light. The blue luminescent diode B emits blue light. These luminescent diodes R, G, and B are arranged at equal intervals along the circumference of the substrate 12. In FIG. 2A, the luminescent diodes R, G, and B are arranged such that the cathode sides face the center of the substrate 12 while the anode sides face outside the substrate 12. The cathodes of the

luminescent diodes R, G, and B are directly connected to a common terminal unit 14 while the anodes are separately connected to terminals 14r, 14g, and 14b through the current control circuit described later.

The protective cover 13 is made of a transmissible material. The transmission can be obtained through a transparent or semitransparent material. However, it is desired that the material is semitransparent and photodiffusible so that the mixing of optical three primary colors can be properly made.

FIG. 3 shows the connection between the variable color LED device 10 and the current control circuit (LED color control device). As shown in FIG. 3, the cathode of each of the luminescent diodes R, G, and B is connected to the terminal unit 14 while the anode of each of them is connected to the terminal units 14r, 14g, and 14b through the variable resistances 16r, 16g, and 16b of the current control circuit 15.

The terminal units 14r, 14g, and 14b are connected to the plus terminal of the power source (not shown in the attached drawings). The common terminal unit 14 is connected to the minus terminal of the power source. The current that flows to the red luminescent diode R can be controlled by adjusting the resistance value of the variable resistance 16r. The size of the

current controls the amount of emission. Likewise, the amount of emission from the luminescent diode G can be controlled by adjusting the resistance of the variable resistance 16g, and the amount of emission from the luminescent diode B can be controlled by adjusting the resistance of the variable resistance 16b.

The variable resistances 16r, 16g, and 16b of the current control circuit 15 are not shown in the attached drawings. They can be provided in the body 11 shown in FIG. 2B, and their variable resistance units are interlocked with a small screw that can be turned optional degrees clockwise or counterclockwise using a driver, etc. externally. Thus, the voltage (current) of the three luminescent diodes R, G, and B for optical three primary colors can be freely controlled. That is, the quantity of light of the luminescent diodes R, G, or B can be optionally controlled while the LED device is powered. Thus, the desired luminescent color can be optionally set while using the driver and watching the entire luminescent color.

Since the variable color LED device 10 of the present invention is provided with the luminescent diodes R, G, and B emitting optical three primary

colors, the variable color LED device can emit any tone of color by mixing the there colors.

For example, when red is required entirely, the resistance value of variable resistance 16r is decreased to power only the red luminescent diode R. The resistance values of other variable resistances 16g and 16b are increased to the maximum values to power off the luminescent diodes B and G. When green is required entirely, only the green luminescent diode G is powered while the luminescent diodes R and B are powered off. Likewise, when blue is required entirely, only the blue luminescent diode B is powered while other luminescent diodes R and G are powered off. When the variable color LED device tries to emit any of the other colors, the resistance value of each of the variable resistances 16r, 16g, and 16b is adjusted to appropriately control the amount of the electric current flowing to the luminescent diode R, G, or B so that optical three primary colors are appropriately mixed to obtain a desired color.

Each of the variable resistances are not provided in the body 11, but can be mounted in an external peripheral device. For example, the terminal units 14r, 14g, 14b, and 14 are formed not as a flexible metal leading line but as a hard metal plug terminal

unit to realize the similar result by setting a variable resistance between the input terminal unit and output terminal unit of the socket coupled to the plug terminal units. In this case, the resistance value can be easily set if the variable resistance is linearly mounted along the axis of the socket with the socket shaped longer at its rear portion. The resistance value can also be set easily by leading from the side of the socket the leading line connecting the socket to the power source, and by providing the setting unit of the variable resistance with the top of a screw arranged at the rear portion of the socket. That is, the socket can be optionally shaped as long as the variable resistance can be properly set.

If a current control circuit is provided inside or outside the above described socket for the variable color LED device, and if the current control circuit is controlled by the display control circuit according to an image signal, then the variable color LED device can also be used as a display picture element of a dynamic image. The control by the display control circuit can be made by preparing a look-up table indicating the relationship between the intensity signal of the image signal and each variable

resistance of the current control circuit through which the display picture element (variable color LED device) emits light (colors). Using the lookup table, an image signal can be converted into a variable resistance control signal.

Thus, a luminescent picture element that emits various colors on a single LED device can be configured according to the present invention. The size of the emitting surface of the LED device is some millimeters long and is very small. Therefore, a very precise image can be obtained when the device is used as a display picture element of an outdoor display device. It is obvious that a precise image can be obtained when the device is used as a display picture element of an indoor display device.

In the above described embodiment, a total of 3 luminescent diodes, each of which is used to emit one of optical three primary colors, are provided in a single LED device. Two luminescent diodes can also be provided for each of optical three primary colors. This application is described below as the second embodiment of the present invention.

FIGs. 4A and 4B show the second embodiment in which two luminescent diodes are provided for each of optical three primary colors. FIG. 4A is a top view

of the variable color LED device. FIG. 4B shows the variable color LED device and the current control circuit for controlling the current. As shown in FIG. 4A, a variable color LED device 20 is provided with a total of six luminescent diodes, that is, two red luminescent diodes R1 and R2, two green luminescent diodes G1 and G2, and two blue luminescent diodes B1 and B2 on a substrate 22.

The variable color LED device 20 shown in FIG. 4A is similar, apart from the number of terminal units, in shape to the body 11 of the variable color LED device 10 shown in FIGs. 2B and 2C as viewed from the side and bottom (although the similarity is not shown in the attached drawings). The variable color LED device 20 is smaller than 5mm in diameter of the emitting surface, and is very small and covered with a protective transmission cover at its top.

In this case, the luminescent diodes R1, R2, G1, G2, B1, and B2 are arranged at equal intervals along the circumference of the substrate 22. As shown in FIG. 4B, the anodes of the luminescent diodes R1, R2, G1, G2, B1, and B2 are connected to the terminal unit 14 while the cathodes of them are connected to the terminal units 14r-1, 14r-2, 14g-1, 14g-2, 14b-1, and 14b-2 through the variable resistances 16r-1, 16r-2,

16g-1, 16g-2, 16b-1, and 16b-2 of a current control circuit 25. That is, a total of 7 terminal units are led from the bottom of the body.

In the case according to the second embodiment, the terminal units 14r-1, 14r-2, 14g-1, 14g-2, 14b-1, and 14b-2 are connected to the plus terminal of the power source while the common terminal unit 14 is connected to the minus terminal of the power source. The amount of emission from the red luminescent diodes R1 and R2 is adjusted by controlling the current with the resistance values of the variable resistances 16r-1 and 16r-2 properly adjusted. Likewise, the amount of emission from the green luminescent diodes G1 and G2 is adjusted by controlling the resistance values of the variable resistances 16g-1 and 16g-2. The amount of emission from the blue luminescent diodes B1 and B2 is adjusted by controlling the resistance values of the variable resistances 16b-1 and 16b-2.

Also in the second embodiment, as in the first embodiment, each of the variable resistances 16r-1 through 16b-1 of the current control circuit 25 can be provided in the body unit, and small screws interlocking with the variable units of the variable resistances are turned using a driver, etc. to adjust the resistance values. Otherwise, the terminal units

14r, 14g, 14b, and 14 are formed as a hard metal plug terminal unit to realize the similar result by setting variable resistances 16r-1 through 16b-2 between the input terminal unit and output terminal unit of the socket coupled to the plug terminal units. In this case, each of the variable resistances 16r-1 through 16b-2 can be controlled using a lookup table through an external display control circuit so that the device can be used as a display picture element of a dynamic image.

Since the second embodiment is two times as many as the above described first embodiment in number of luminescent diodes, the amount of emission from the luminescent diode is two times as much from the entire variable color LED device 20. Therefore, even if the device is used outdoors as a display picture element of the display device, sufficient amount of emission (intensity) can be obtained, thereby forming a precise image.

According to the above described embodiment, the variable resistance and terminal on the anode side are arranged such that they corresponds one by one to each luminescent diode. However, the arrangement and connection of the variable resistance and terminal on the anode side to the luminescent diode are not

limited to this embodiment. Described below as other embodiments are the arrangement and connection of the variable resistance and terminal on the anode side to the luminescent diode.

FIG. 5A shows the variable color LED device and the current control circuit for controlling the current according to the third embodiment. As in the second embodiment, a variable color LED device 30 is provided with 6 luminescent diodes, and their cathodes are connected to the common terminal 14. According to the embodiment, on the anode sides, luminescent diodes R1 and R2 are connected in parallel, luminescent diodes G1 and G2 are connected in parallel, and luminescent diodes B1 and B2 are connected in parallel to the output terminals of the variable resistances 36r, 36g, and 36b respectively for each color. The input terminals of the variable resistances 36r, 36g, and 36b are connected to the terminals 34r, 34g, and 34b. This is the only difference of the third embodiment from the second embodiment. That is, according to the third embodiment, two luminescent diodes are provided for each color of optical three primary colors. The current for the luminescent diodes can be controlled not individually as in the second embodiment, but

collectively controlled for a pair of luminescent diodes for the same color. In this case, when the variable color LED device 30 is combined with a current control circuit 35, a total of 4 terminal units are led.

FIG. 5B shows the variable color LED device and the current control circuit for controlling the current according to the fourth embodiment. In this embodiment, a variable color LED device 40 is provided, as in the second and third embodiments, the luminescent diodes R1, R2, G1, G2, B1, and B2 with a pair of the diodes mounted for each of optical three primary colors. However, according to the fourth embodiment, the luminescent diodes are connected in series for each color, and a pair of luminescent diodes connected in series for each color (red luminescent diodes R1 and R2; green luminescent diodes G1 and G2; and blue luminescent diodes B1 and B2) are respectively connected to the output terminals of the variable resistances 46r, 46g, and 46b respectively. The input terminals of the variable resistances 46r, 46g, and 46b are connected to the terminal units 44r, 44g, and 44b respectively. This is the difference between the third and fourth embodiments. In the fourth embodiment, a total of four terminal units are

led with the configuration of the variable color LED device 40 combined with the current control circuit 45.

The variable color LED device and current control circuit can be configured as not being combined with each other in the third and fourth embodiments. That is, the current control circuit can be connected as an external device to the variable color LED device through a socket, etc. Also the variable resistance can be controlled on the display in real time according to the image signal using the display control device and lookup table.

FIG. 6 shows the variable color LED device according to the fifth embodiment and the current control circuit for controlling the current. FIG. 7A shows the variable color LED device according to the sixth embodiment and the current control circuit for controlling the current. FIG. 7B shows the variable color LED device according to the seventh embodiment and the current control circuit for controlling the current.

A variable color LED device 50 shown in FIG. 6 according to the fifth embodiment is provided with a total of nine luminescent diodes, that is, three red luminescent diodes R1, R2, and R3; three green

luminescent diodes G1, G2, and G3; and three blue luminescent diodes B1, B2, and B3 on the substrate.

The variable color LED device 50 shown in FIG. 6 is also similar in shape, apart from the number of terminal units, to the body 11 of the variable color LED device 10 shown in FIGs. 2B and 2C as being viewed from the side and bottom. However, the similarity is not shown in the attached drawings. The variable color LED device 50 can also be formed about 7 or 8 mm in diameter of the luminescent surface, and the device is covered with a transmissible protective cover.

The luminescent diodes R1, R2, ..., B2, and B3 are arranged along the circumference of the substrate at equal intervals. The anodes are connected to the common terminal unit 14 while the cathodes are connected to the terminal units 14r-1, 14r-2, 14g-1, 14g-2, 14b-1, and 14b-2 through the variable resistances 56r-1, 56r-2, 56r-2, 56g-1, 56g-2, 56g-3, 56b-1, 56b-2, and 56b-3 of a current control circuit 55. That is, if the variable color LED device 50 is combined with the current control circuit 55, a total of 10 terminal units are led from the bottom of the body.

In this example, terminal units 54r-1 through 54b-

3 are connected to the plus terminal of the power source (not shown in the attached drawings), and the common terminal unit 14 is connected to the minus terminal of the power source. The amount of emission from the red luminescent diodes R1 through R3 is controlled based on the resistance values of the variable resistances 56r-1 through 56r-3. The amount of emission from the green luminescent diodes G1 through G3 is controlled based on the resistance values of the variable resistances 56g-1 through 56g-3. The amount of emission from the blue luminescent diodes B1 through B3 is controlled based on the resistance values of the variable resistances 56b-1 through 56g-3.

A variable color LED device 60 according to the sixth embodiment shown in FIG. 7A is, as in the fifth embodiment, is provided with a total of 9 luminescent diodes. The cathodes are connected to the common terminal unit 14 while the anodes of the three luminescent diodes for each color are connected to the output terminals of variable resistances 66r, 66g, and 66b in series. The input terminals of the variable resistances 66r, 66g, and 66b are connected to terminals 64r, 64g, and 64b. This is the difference between the fifth and sixth embodiments. That is,

according to the sixth embodiment, three luminescent diodes are provided for each of optical three primary colors. The current that flows to the luminescent diodes is not individually controlled as in the fifth embodiment, but a set of three luminescent diodes is collectively controlled for the same luminescent color. If the variable color LED device 60 is combined with a current control circuit 65, a total of 4 terminal units are led from the device.

A variable color LED device 70 according to the seventh embodiment shown in FIG. 7B is the same as the device according to the fifth and sixth embodiments in that the three red luminescent diodes R1, R2, and R3, three green luminescent diodes G1, G2, and G3, and three blue luminescent diodes B1, B2, and B3 are provided for respective colors of optical three primary colors. However, according to the seventh embodiment, three luminescent diodes are connected in series for each color, and a set of three luminescent diodes connected in series (red luminescent diodes R1, R2, and R3; green luminescent diodes G1, G2, and G3; and blue luminescent diodes B1, B2, and B3) are connected to the output terminals of variable resistances 76r, 76g, and 76b respectively. The input terminals of the variable resistances 76r, 76g, and

76b are connected to terminal units 74r, 74g, and 74b. This is the difference between the fifth and sixth embodiments. In this embodiment, if the variable color LED device 70 is combined with a current control circuit 75, a total of 4 terminal units are led from the device.

In the fifth, sixth, and seventh embodiments, the variable color LED device is not combined with the current control circuit, but the current control circuit can be connected as an external device to the variable color LED device through a socket, etc. The variable resistance can be controlled on the display in real time according to the image signal using the display control device and lookup table.

FIG. 8 shows an example of the variable color LED device configured to emit various luminescent colors limited by the seventh embodiment. The variable color LED device shown in FIG. 8 is provided with eight chip resistances 87 having respective resistance values, two red luminescent diodes R, four green luminescent diodes G, and two blue luminescent diodes B on a substrate 82. Thus, the luminescent diodes do not have to be equal in number for each color. In other words, since the quantity of light of each of the optical three primary colors is predetermined to emit

a requested color, the number of the luminescent diodes can be determined according to the predetermined quantity of light for each of the optical three primary colors. Furthermore, appropriately switching the connections to the chip resistances enables a desired color to be emitted from among limited variations of colors. If a trimming resistance (variably set as a resistance value by trimming a resistance chip using, for example, a laser light) is used as a chip resistance for controlling the current of the variable color LED device, the resistance value can be optionally varied.

As described above, any number of luminescent diodes can be used for each of optical three primary colors in the variable color LED device of the present invention. It is obvious that the larger the number of the luminescent diodes is, the larger quantity of light is emitted. The configuration of the current control circuit and the connection to the current control circuit can be controlled depending on the configuration in each embodiment. Additionally, since a light of any color can be emitted on a single variable color LED device, the functions of a plurality of conventional emitting devices can be performed by a single emitting device (variable color

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LED device).

FIG. 9 shows an application of the variable color LED device for use in the traffic signal lamps. It shows a new variable color LED device according to the present invention below a traffic signal lamp shown just for comparison. The traffic signal lamp shown in FIG. 9 comprises a red signal lamp 84; a yellow signal lamp 85: and a green signal lamp 86. It functions as traffic signal lamps by sequentially emitting the three colors. That is, three emitting devices are used to exclusively emit a specified color. On the other hand, using the variable color LED device according to the present invention, the system comprises only one signal lamp 87. The current control circuit controls for each color the electric current to the luminescent diode. When the variable color LED device indicates red, it emits red light. When the variable color LED device indicates yellow, it emits yellow light. When the variable color LED device indicates green, it emits green light.

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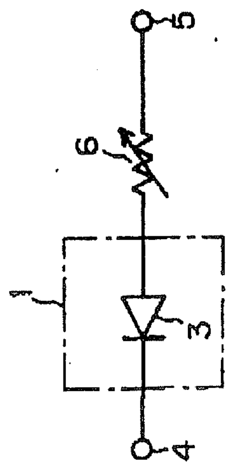


FIG. 1B

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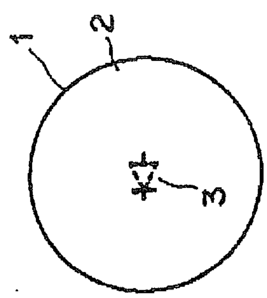


FIG. 1A

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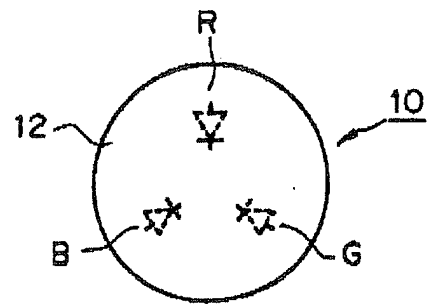


FIG. 2A

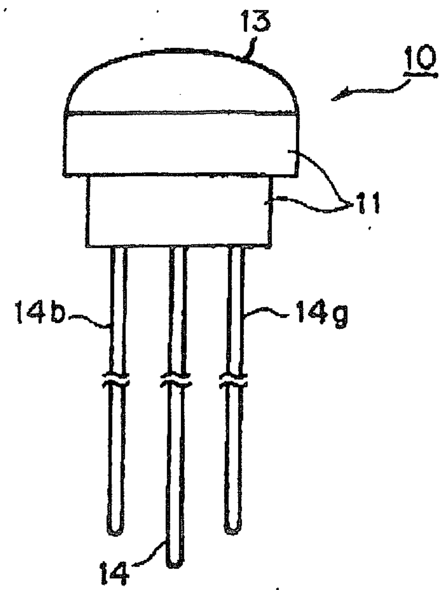


FIG. 2B

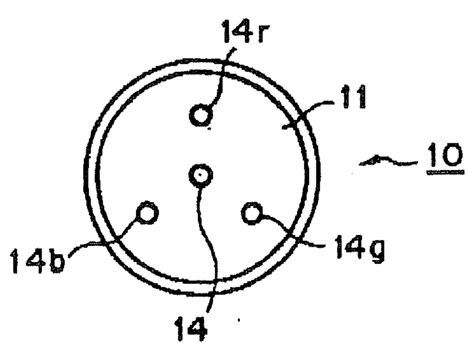


FIG. 2C

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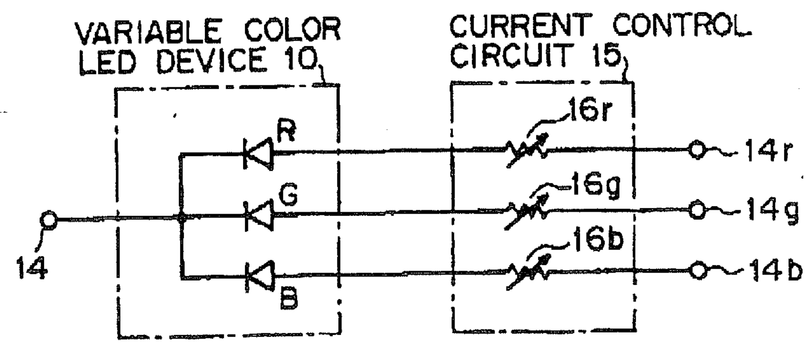


FIG. 3

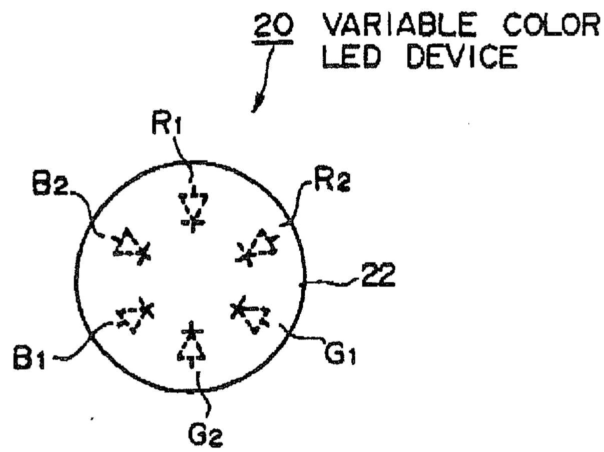
20 VARIABLE COLOR LED DEVICE
R1
R2
B2
22
B1
G1
G2

FIG. 4A

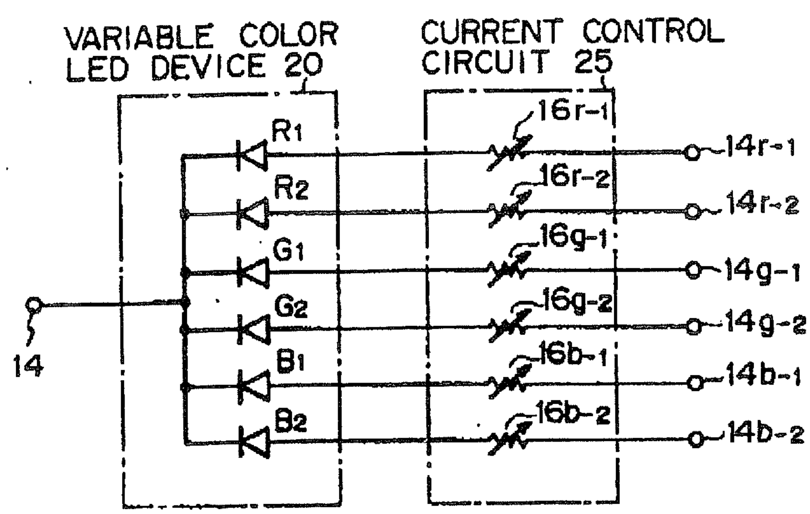
VARIABLE COLOR LED DEVICE 20
CURRENT CONTROL CIRCUIT 25
R1
R2
G1
G2
B1
B2
14
16r-1
16r-2
16g-1
16g-2
16b-1
16b-2
14r-1
14r-2
14g-1
14g-2
14b-1
14b-2

FIG. 4B

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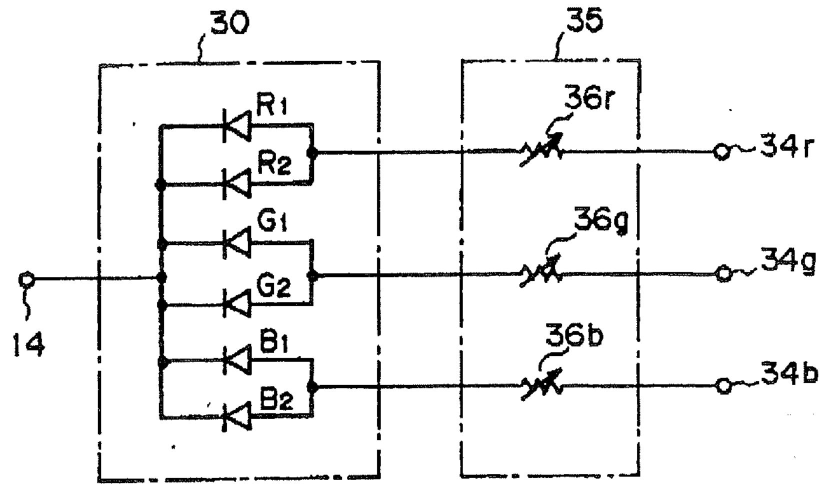


FIG. 5A

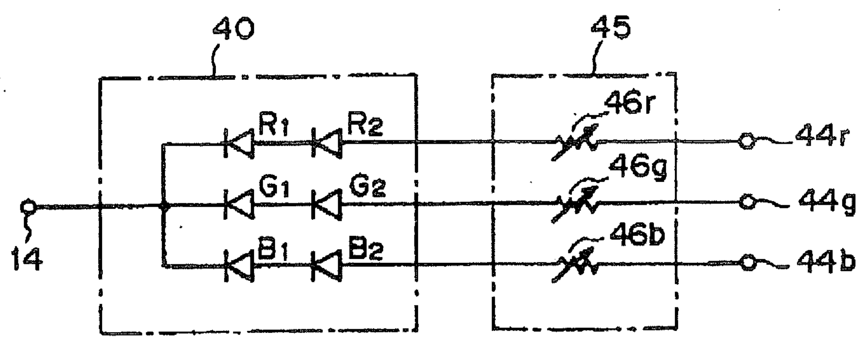


FIG. 5B

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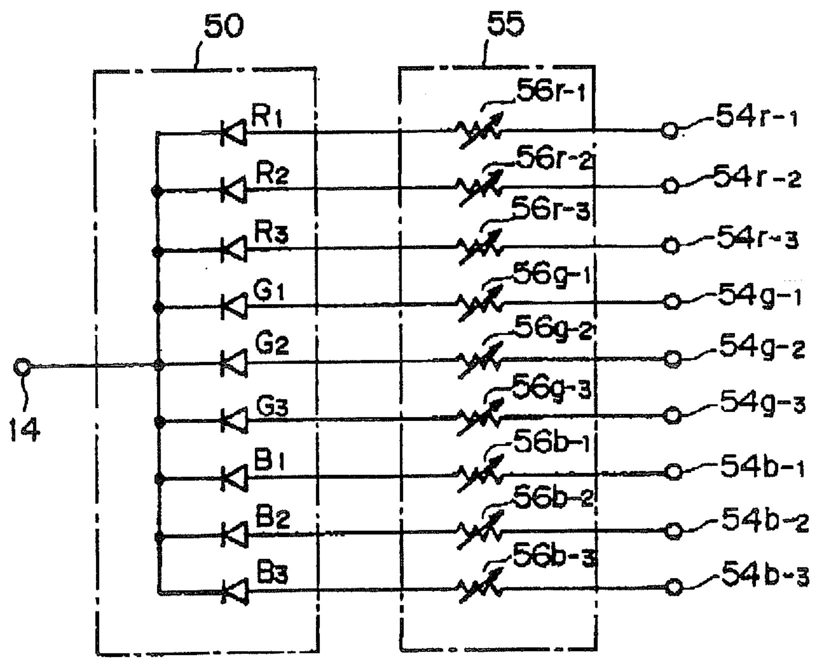


FIG. 6

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Fetherstonhaugh & Co.

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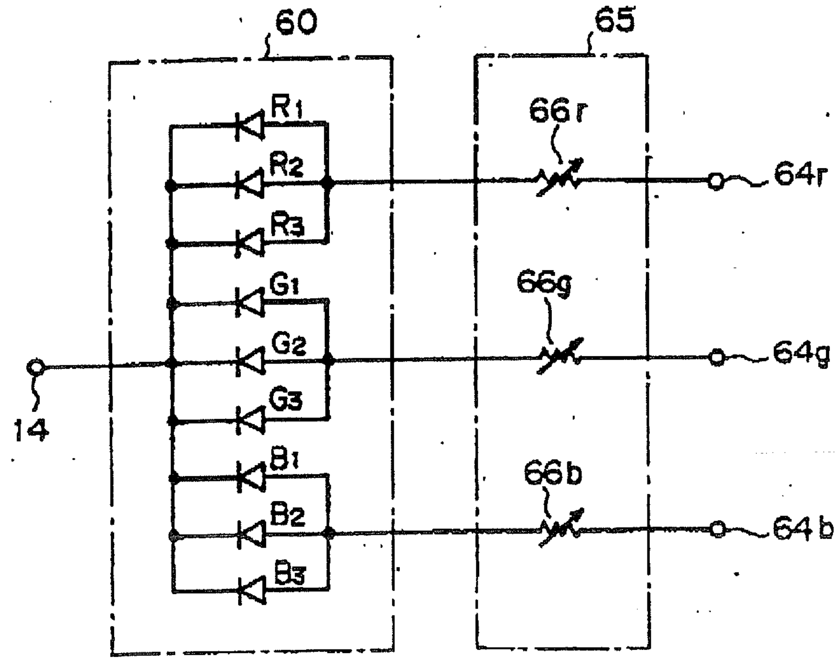


FIG. 7A

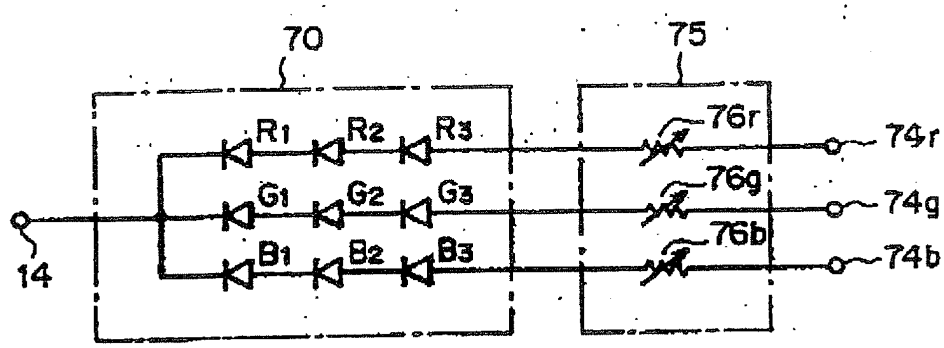


FIG. 7B

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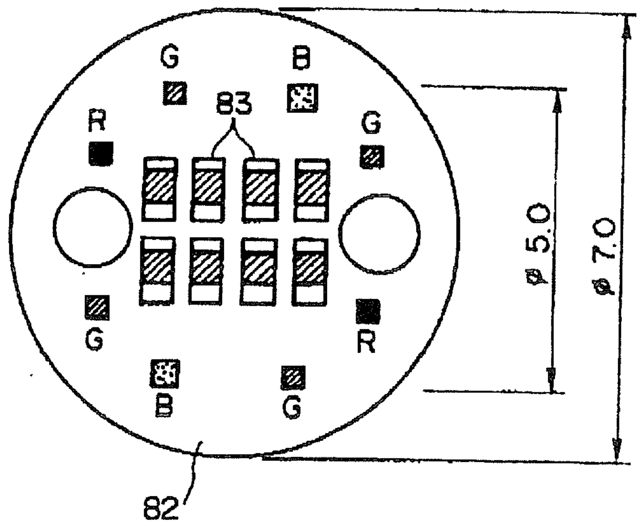


FIG. 8

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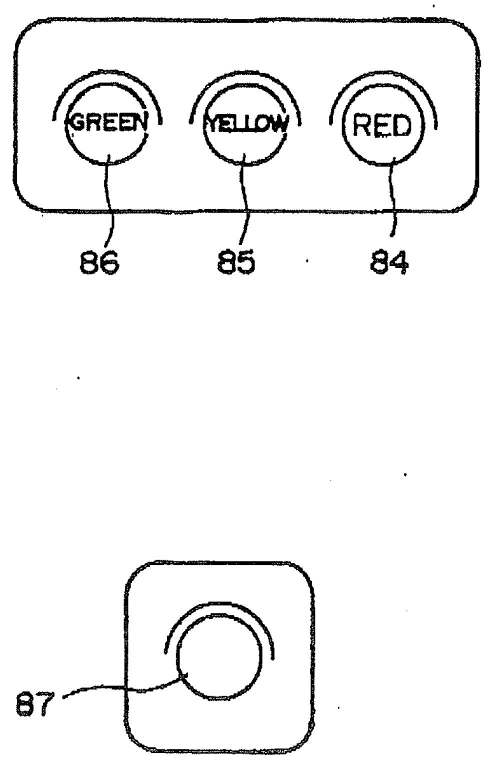


FIG. 9